Advances in computational intelligence and learning

Biehl, Michael; Merényi, Erzsébet; Rossi, Fabrice

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Editorial

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This special issue of *Neurocomputing* presents 18 original articles which are extended versions of selected papers from the 14th European Symposium on Artificial Neural Networks (ESANN).

ESANN is a single track conference held annually in Bruges, Belgium, one of the most beautiful medieval towns in Europe. ESANN is organized by Prof. Michel Verleysen from Université Catholique de Louvain, Belgium. In addition to regular sessions, the conference welcomes special sessions focused on particular topics such as man–machine interface, online learning, semi-blind source separations, etc. The contributions in this special issue show that ESANN covers a broad range of topics in neural computation and neuroscience from theoretical aspects to state-of-the-art applications to many related themes in signal processing, machine learning, and computational intelligence.

More than 120 researchers from 19 countries participated in the 14th ESANN in April, 2006, presented 104 contributions, and enjoyed the especially communicative atmosphere in Bruges. Based on the recommendation of special session organizers, the reviews of the conference papers, and the quality of presentations made at the conference, a number of authors were invited to submit an extended version of their conference paper for this special issue of *Neurocomputing*. All of these articles were thoroughly reviewed once more by at least two independent experts and, finally, the 18 articles presented in this volume were accepted for publication.

The first four papers are concerned with biologically inspired models. Herzog et al. study connection strategies in neocortical neural networks during their development stage. It is known that random local connections have no capability to build a network in which synchronization between neurons is easily achieved. Moreover, global random connections and small-world models are not biologically plausible. The authors analyze a recently proposed *displaced connection strategy* that is both biologically plausible and very effective in terms of wiring cost. The ability of neurons to regulate their firing activities by adaptation of their excitability has been called *intrinsic plasticity*. N. Butko and J. Triesch show in their paper how a network of such units can perform non-linear independent component analysis. They also argue that intrinsic plasticity may play a key role for the learning of sensory representations in the visual cortex. Patel et al. present a bio-inspired engineering approach to harnessing the wave power of large water bodies. By mimicking and "outevolving" a biological system, the lamprey's ability to propel itself using the power of the waves under a wide range of physical circumstances, they make an important step toward optimizing the performance of articulated wave energy converters through the use of biomimetic controllers. Garcia-Pedrajas and Fyfe put forward a new method of constructing classifier ensembles using an Artificial Immune System (AIS), based on Immune Network Theory. The AIS models key aspects of the natural immune system. These authors' innovative approach within the relatively novel paradigm of AIS produces an ensemble of classifiers with demonstrated powerful performance.

The next two papers address transient computation, a term that has been coined for systems in which input signals result in characteristic changes of the internal dynamics. Crook demonstrates that a system of only two non-linear neurons is capable of performing non-trivial computations on time-dependent signals, e.g., noise-resistant pattern recognition. Lourenço discusses a system of biologically plausible neurons which displays spatio-temporal chaos and he shows that this system provides a reservoir of dynamical states that can be used for computational tasks.

A dynamic approach is also at the heart of the two following papers. Girau and Torres-Huitzil outline a digital hardware design that models spiking neural networks, more specifically LEGION networks, for the purpose of image segmentation. The novelty in this digital implementation is that it can handle the large-scale spiking neural networks needed for real-life applications, unlike earlier attempts that could not compete with analog devices. This achievement is due to taking advantage of the local and distributed structure of the model, which in turn enables massively distributed realization in FPGAs. Tang and Murray tackle the difficult problem of classifying non-linearly separable clusters of sensor data under hostile circumstances that often affect wireless, embedded sensors and which cause dynamic drift in sensor measurements (e.g., miniature pH sensors in the gastrointestinal track).

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They employ a Continuous Restricted Boltzmann Machine that is able to autonomously adjust to sensor drift by adaptive sensor fusion and can, consequently, correctly classify complex data.

The work by Vrins and Pham also benefits sensor signal processing. These authors focus on the theoretical analysis of a blind source separation method. They consider partial simultaneous extraction, i.e., when one tries to simultaneously extract P sources from K linearly independent mixtures of K independent sources ($P \leqslant K$). They show that the minimum-range contrast has a unique maximum in this context, and therefore any local optimization technique will lead to the global maximum and consequently to an exact recovery of the sources.

The next group of three papers deals with prototype-based learning methods and vector quantization. Schleif et al. propose and investigate a query strategy for Learning Vector Quantization. The selection of data close to the current decision boundary is shown to improve the achieved generalization ability and the convergence speed. Hammer et al. investigate the relation between the density of prototypes and the underlying data distribution, the so-called magnification factor. The authors propose a scheme for magnification control in the batch version of Neural Gas training and demonstrate its usefulness for sampling rare events in a real data set. An enhanced Vector Quantization method is applied in Steil et al. in the context of real-time image segmentation. A hierarchy of adaptive scene-dependent filters is proposed and applied in a biologically motivated learning architecture for object recognition.

Kernel machines are studied in the following two papers. Schrauwen and Campenhout analyze the problem of the definition of kernel functions adapted to spike trains. Rather than binning the trains, the proposed kernel functions enable their native processing and as a consequence it is robust to jitter-induced noise. In addition, this work offers a unifying view of recent specialized metrics for spike trains. Szedmak and Shawe-Taylor propose a solution to the complex problem of semi-supervised learning with two sources as well as a theoretical analysis of its properties. The algorithm belongs to the class of maximum margin kernel methods. The main idea of the method is to use unlabeled data as a way to reduce the complexity (in the sense of the Rademacher complexity theory) of the set of functions that can be learned, so as to improve the generalization performance.

The next two contributions focus on variable (or feature) selection. A key problem in time-series regression or forecasting is addressed in the paper by Simon and Verleysen. The authors suggest a heuristic criterion for the fast selection of all delays in high-dimensional phase space reconstruction. Its usefulness is demonstrated in the context of artificial and real benchmark time series. Franç ois et al. offer an information theoretical approach to feature extraction, where the relative importance of data dimensions is determined based on a mutual information criterion combined with re-sampling methods. This results in a parameter-free and robust determination of the relevant features, which is also more reliable than feature selection with estimation of the mutual information alone, for high-dimensional data.

The last two articles of this special issue are devoted to non-linear projection methods, an important problem in both machine learning and information visualization. Klanke and Ritter propose an extension of their recently introduced manifold learning method, *Unsupervised Kernel Regression*. This extension enables the use of non-Euclidean general cost functions which in turn leads to increased robustness and to the possibility of using prior information to adapt the cost function to the assumed noise distribution. While non-linear projection methods (such as manifold learning algorithms studied in the previous paper) have made considerable progress recently, it remains difficult for users to assess visually the quality of a projection and to avoid drawing false conclusions from distorted structures. Aupetit introduces several auxiliary quantities that can be visualized and superimposed on a two-dimensional scatter plot resulting from a projection. These visualized auxiliary data show, in a very clear way, which parts of the plot can be trusted and which correspond to artifacts induced by the projection.

The articles of this special issue cover a broad variety of topics. This diversity phenomenon has been a continuing aspect for some years now as neural computation, and more generally, soft computing and machine learning, are gaining application in more and more areas, inspired and pushed by real-life challenges and hard theoretical problems alike. ESANN each year stimulates and harvests some of the cutting-edge work responding to such challenges, and we are pleased to present a sampling of these works in an extended form in this special issue of *Neurocomputing*.

The guest editors would like to thank all authors for their submissions and the reviewers for their excellent work. Both authors and reviewers have been asked to work under a very tight schedule that has enabled the publication of this issue in less than a year after the conference, in a timely manner before the ESANN 2007 meeting. We would also like to thank the *Neurocomputing* editorial board for giving us the opportunity to publish this issue, and Elsevier as the publisher for the very efficient and seamless management of the publication procedure, which also contributed greatly to the meeting of a tight publication schedule.

Our most sincere gratitude goes to Professor M. Verleysen for his strong support of this special issue and for the excellent job he has done organizing the conference. An increasing number of submissions and regular participants emphasizes the high standing this conference has achieved under Professor Verleysen's leadership in Europe and worldwide. It is a pleasure for us to invite all authors

and interested readers of this issue to future ESANN conferences, which are announced at http://www.dice.ucl.ac.be/esann.

Michael Biehl
University Groningen, Groningen, The Netherlands

Erzsébet Merényi
Rice University, Houston, TX, USA

Fabrice Rossi
Project AXIS, INRIA Rocquencourt, France
E-mail address: Fabrice.Rossi@inria.fr